AD-A272 114



1 OCTOBER 1992 THROUGH 30 SEPTEMBER 1993 CONTRACT N00014-89-J-1070



SIGNAL PROCESSING IN THE LINEAR STATISTICAL MODEL

PRINCIPAL INVESTIGATOR: Louis L. Scharf, 303/492-8283
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY OF COLORADO
BOULDER, CO 80309-0425



Reproduction in whole or in part is permitted for any purpose of the United States Government.

This document has been approved for public release and sale; its distribution is unlimited.

93-26538 |||||||_{5/93}

form Approved REPORT DOCUMENTATION PAGE DAME NO CONTACT Fublishment of the first of the properties of th 1. AGENCY USE ONLY (Leave DIANK) 2 REPORT DATE 3. REPORT TYPE AND DATES COVERED Annual, 10/1/92 - 9/30/9310/20/93 4. TITLE AND SUBTITLE 5 FUNDING NUMBERS Signal Processing in the Linear Statistical Model N00014-89-J-1070 - Annual Report 1993 6. AUTHOR(S) Louis L. Scharf and Clifford T. Mullis 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) 8. PERFORMING ORGANIZATION REPORT NUMBER Electrical & Computer Engineering University of Colorado AR 1993 Campus Box 425 Boulder, CO 80309-0425 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) --10. SPONSORING / MONITORING -AGENCY REPORT NUMBER Office of Naval Research Statistics & Probability Branch Mathematics Division 800 North Quincy Avenue Arlington, VA 22217 11. SUPPLEMENTARY NOTES 12a. DISTRIBUTION / AVAILABILITY STATEMENT 12b. DISTRIBUTION CODE Unclassified 13. ABSTRACT (Maximum 200 words) This research program has produced the following results: (1) a method of estimating power spectra using multiple orthogonal time-division windows; (2) an exact likelihood procedure for estimating frequencies and arrival angles for propagating plane waves that are detected by multisensor arrays; (3) a theory of oblique projections for solving estimation problems; (4) a method for designing matched subspace detectors for detecting subspace signals in subspace interference; (5) a method for designing data-adaptive and reduced-rank estimators for solving least squares problems; and (6) a method for bounding the probability of a subspace swap in SVD methods. Work is continuing on (1) general quadratic performance bounds for estimation; (2) complex exponential frames for modeling discrete-time sequences; (3) discrete wavelet frames and filter banks; (4) projection operator decomposition of ℓ_2 ; and (5) representation and synthesis of periodicallycorrelated time series using subband decompositions. 14. SUBJECT TERMS 15. NUMBER OF PAGES

NSN 7540-01-280-5500

OF REPORT

17. SECURITY CLASSIFICATION

Unclassified

18. SECURITY CLASSIFICATION

OF THIS PAGE

Unclassified

Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std 239-18 298-102

20. LIMITATION OF ABSTRACT

16. PRICE CODE

19. SECURITY CLASSIFICATION

OF ABSTRACT Unclassified

ONR PUBLICATIONS/PATENTS/PRESENTATIONS/HONORS REPORT 1 October 1992 through 30 September 1993

R&T Number:

Contract/Grant Number: N00014-89-J-1070

Contract/Grant Title: Signal Processing in the Linear Statistical Model

Principal Investigators: Louis L. Scharf and C. T. Mullis

Mailing Address: Electrical & Computer Engineering, Box 425

University of Colorado Boulder, CO 80309-0425

Phone Number: (303) 492-8283 E-Mail Address: scharf@prony.colorado.edu, mullis@prony.colorado.edu

- a. Number of Papers Submitted to Refereed Journals but not yet published: 9 (list attached)
- b. Number of Papers Published in Refereed Journals: 1 (list attached)
- c. Number of Books/Chapters Submitted but not yet Published: 0 (list attached)
- d. Number of Books or Chapters Published: 0
- e. Number of Technical Reports & Non-Refereed Papers: 0
- f. Number of Patents Filed: 0
- g. Number of Patents Granted: 0
- h. Number of Invited Presentations at Workshops or Professional Society Meetings: 2 (list attached)
- i. Number of Contributed Presentations at Workshops or Professional Society Meetings: 6 (list attached)
- j. Honors/Awards/Prizes for Contract/Grant Employees: 2 (list attached)
- k. Total number of Graduate Students and Post-Docs Supported at Least 25% This Year Under This Grant: Graduate Students: 2 Post-Docs: 1

Of these:

Female Graduate Students: 0 # Female Post-Docs: 0 # Minority Graduate Students: 0 # Minority Post-Docs: 0

Note: Minorities includes African Americans, Hispanics, American Indians, and Aleutians only.

l. (added by PI) Work in Progress: 5

Accesion For

NTIS CERTI N
DTIC 1975 Distribution

By
Distribution/
Availability Codes

Distribution/
Special

OUTCOTAL TV HOPPICTED 5

- a. Papers submitted to refereed journals (and not yet published):
 - M. P. Clark and L. L. Scharf. "Two-Dimensional Modal Analysis Based on Maximum Likelihood." accepted and to be published in *!EEE Trans Signal Proc* (June 1994).
 - R. T. Behrens and L. L. Scharf, "Signal Processing Applications of Oblique Projection Operators." accepted and to be published in *IEEE Trans Signal Proc* (1993).
 - L. L. Scharf and S. T. Voran, "Polar Coordinate Quantizers," accepted and to be published in IEEF Trans Signal Proc (1994).
 - A. J. Thorpe and L. L. Scharf, "Data Adaptive Reduced-Rank Methods for Solving Least Squares Problems," submitted to IEEE Trans Signal Proc (1994).
 - M. Vis and L. L. Scharf, "A Note on Recursive Maximum Likelihood for Autoregressive Modeling." submitted to IEEE Trans Signal Proc (September 1993).
 - L. L. Scharf and B. Friedlander, "Matched Subspace Detectors," submitted to IEEE Trans Signal Proce (July 1993).
 - K. Aas and C. T. Mullis, "Minimum Mean-Squared Error Transform Coding and Subband Coding," submitted to IEEE Trans Signal Proc (January 1993).
 - L. L. Scharf and S. T. Voran, "Noise Rejecting Quantizers," submitted to IEEE Trans Signal Proc (January 1993).
 - J. K. Thomas, L. L. Scharf, and D. W. Tufts, "Probability of Subspace Swap in the SVD," submitted to IEEE Trans Signal Proc (July 1993).
- b. Papers published in refereed journals:
 - M. P. Clark and C. T. Mullis, "Quadratic Estimation of the Power Spectrum using Orthogonal Time-Division Multiple Windows," *IEEE Trans on Signal Proc* SP-41:1 (January 1993).
- c. Books (and sections thereof) submitted for publication:

None.

d. Books (and sections thereof) published:

None.

e. Technical reports and nonrefereed papers:

None.

f. Patents filed:

None (one in preparation).

g. Patents granted:

None.

- h. Invited presentations at topical or scientific/technical society conferences:
 - L. L. Scharf and B. Friedlander, "Matched Subspace Detectors," 1993 Workshop on Underwater Acoustic Signal Processing, Kingston, RI (September 1993).

- L. L. Scharf and L. T. McWhorter, "Quadratic Estimators of Covariance: Theory and Application," to be presented at SYSIN, Copenhagen (July 1994).
- 1. Contributed presentations at topical or scientific/technical society conferences:
 - M. P. Clark and L. L. Scharf, "Frequency-Wavenumber Spectrum Analysis." Proc 1992 Workshop on Statistical and Array Processing, Victoria, BC (October 1992).
 - M. Spurbeck, "Causal Wiener Filtering of Periodically Correlated Sequences," SIAM Conf on Linear Algebra, Signal Systems, and Controls, Seattle (August 1993).
 - M. P. Clark and L. L. Scharf, "Efficient Frequency-Wavenumber Spectrum Estimation using Sliding Time-Division Windows," 1992 Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA (November 1992).
 - J. K. Thomas, L. L. Scharf, and D. W. Tufts, "Probability of Subspace Swap in the SVD," to be presented at 27th Annual Asilomar Conf on Signals, Systems, and Computers, Asilomar, CA (October 1993).
 - L. L. Scharf and B. Friedlander, "Matched Subspace Detectors," to be presented at 27th Annual Asilomar Conf on Signals, Systems, and Computers, Asilomar, CA (October 1993).
 - L. L. Scharf, "Geometrical Ideas in Detection, Estimation, and Time Series Analysis," to be presented at 7th SP Workshop on Statistical Signal and Array Processing, Quebec City (June 1994).
- j. Honors/awards/prizes:
 - C. T. Mullis promoted to full Professor effective January 1, 1993.
 - L. L. Scharf appointed National Distinguished Lecturer for IEEE Society for Signal Processing (1993-1994).
- k. Graduate students and post-doctorals supported under the contract for the year ending 1 October 1993: (no female/minority)

John K. Thomas Mark Spurbeck Knut Aas (post-doctoral)

l. Work in Progress:

- F. Ziel and C. T. Mullis, "Discrete Wavelet Frames and Filter Banks," to be submitted to IEEE Trans Signal Proc.
- J. K. Thomas, "Automatic Bandwidth Estimation in Spectral Analysis," to be submitted.
- M. Spurbeck, "Wavelet Decompositions of ℓ^2 ," to be submitted.
- L. L. Scharf and M. Vis, "Signal Subspace MUSIC Algorithm," to be submitted.
- J. K. Thomas, "Nonstationary Spectrum Analysis," to be submitted.